

INTERSUBMARINE SPEECH INTELLIGIBILITY LEVELS

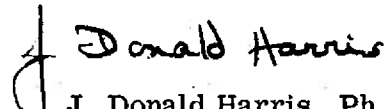
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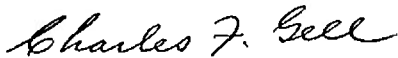
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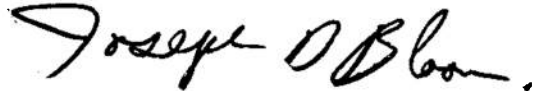
  
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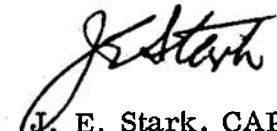
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## SUMMARY PAGE

### THE PROBLEM

To determine speech intelligibility levels between submarines using standard submarine communication units.

### FINDINGS

Speech intelligibility scores ranged from 31.0 to 79.4 percent. The intelligibility scores appeared to vary as a result of the mode of transmission and reception and as the result of depth of the transmitter and receiver units.

### APPLICATION

The results of this study deal directly with the problem of communication between two submarines. The results suggest that directional transmission is superior and should be implemented when the two submarines are operating at the same depth. Conversely when operation is at two different depths an omnidirectional transmission mode is suggested.

### ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Research Work Unit M4306.03-2020D, Evaluation of Verbal Communications by Navy Divers and Swimmers and of Sensory Aspects of Inter-Submarine Communications. The present report is No. 04 on the above Work Unit. It was approved for publication on 8 March 1971 and designated as Submarine Medical Research Laboratory Report No. 658.

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## ABSTRACT

The purpose of this investigation was to determine levels of speech intelligibility between two submarines using standard transmitting and receiving units while in operation. Transmission and reception of prerecorded and live voice word lists was made using an AN/WQC-2 sonar unit with directional and omnidirectional transducer arrays. The lists were recorded at the point of reception and played back to listeners for an evaluation of the speech intelligibility. The results indicate that the intelligibility scores were highest when reception was directional and both the transmitter and receiver were at the same depth. The live voice tests showed slightly higher intelligibility scores than the prerecorded lists. It would appear that further tests on reception mode incorporating such variables as range, depth, and speed of the ships are necessary to generalize to more operating conditions than those tested in this study.



# INTERSUBMARINE SPEECH INTELLIGIBILITY LEVELS

## INTRODUCTION

Speech intelligibility testing has proven to be a valuable tool in the assessment of communication networks used by Navy personnel. Moreover, controlled evaluations of speech in various environments have resulted in the design and construction of equipment for use in places previously considered to be beyond the limits of satisfactory voice communication. With regard to the problem of speech transmission between submarines, there is little documented evidence to suggest that one type of transmission/reception network is superior to others.

The fact that submarines operate at a multitude of depths and distances would prohibit a complete evaluation of communication during actual operating conditions using speech intelligibility procedures; however, data from a representative set of conditions may provide a basis for predicting the intelligibility under similar conditions. The present study sought to provide preliminary information on the speech intelligibility levels between two submarines using directional and omnidirectional modes of transmission and reception. This investigation was carried out as a part of a more comprehensive investigation of intersubmarine communication networks.

## PROCEDURE

In order to assess the differences between directional and omnidirectional

speech transmission and reception, pre-recorded and live transmissions of the Modified Rhyme Test<sup>1</sup> were sent from one submarine to another in one of two modes, directionally or omnidirectionally. Reception at the second submarine was also in either the directional or omnidirectional mode. Recordings of all transmissions were made and later presented to panels of listeners in order to obtain intelligibility scores for the various conditions.

Figure 1 is a block diagram of the communications equipment used to transmit and receive the speech material. The test materials were recorded by one adult male speaker using the microphone and preamplifier of a standard AN/WQC-2 voice communication system, coupled to an Ampex PR-10 magnetic tape recorder. A calibration tone of 1.45 kHz (35 millivolts) was included on the tape prior to each list in order to equate the playback loudness of the lists. The same unit was used for the live voice presentation aboard the submarines. The pre-recorded tapes and the live voice lists were transmitted from one submarine either directionally or omnidirectionally and received at the other in either of the two modes. As shown in Figure 1, transmission from Boat A to Boat B was through the AN/WQC-2 sonar unit coupled to a AN/BQS-13 transmitter. The directional receiver system located approximately 50 kiloyards away was made up of an AN/BQS-2 receiving system coupled to the AN/WQC-2 unit and fed to an Ampex PR-10 magnetic tape recorder. For the omnidirectional

TABLE 1. Intersubmarine Speech Intelligibility Scores

| MODE <sup>1</sup>                               | X-MTR<br>Depth<br>(Feet) | RCVR<br>Depth<br>(Feet) | Word<br>List      | % INT.           | S. D. |
|---|--------------------------|-------------------------|-------------------|------------------|-------|
| 3   | >400                     | 400                     | B-1               | 54.3             | 5.1   |
| 3   | 100                      | 100                     | A-9               | 73.4             | 5.7   |
| 3   | 100                      | 100                     | B-9               | 68.9             | 7.3   |
| 3   | 100                      | 100                     | B-14 <sup>2</sup> | <u>81.0</u>      | 5.7   |
|   |                          |                         |                   | $\bar{X} = 74.4$ |       |
| 4   | 100                      | 100                     | B-10              | 39.8             | 7.2   |
| 4   | 100                      | 100                     | C-10              | 31.0             | 8.0   |
| 4   | 100                      | 100                     | C-3 <sup>2</sup>  | <u>65.0</u>      | 7.3   |
|   |                          |                         |                   | $\bar{X} = 45.2$ |       |
| 5   | 400                      | >400                    | A-5               | 79.4             | 5.7   |
| 5   | 100                      | 100                     | A-11              | 78.2             | 5.7   |
| 5   | 100                      | 100                     | C-11              | 75.4             | 6.6   |
| 5   | 100                      | 100                     | C-6 <sup>3</sup>  | <u>66.6</u>      | 6.0   |
|   |                          |                         |                   | $\bar{X} = 73.4$ |       |
| 5(15) <sup>4</sup>                              | 100                      | 100                     | A-12              | 68.5             | 5.5   |
| 5(15)   | 100                      | 100                     | B-12              | 67.2             | 7.0   |
| 5(15)   | 100                      | 100                     | C-12 <sup>3</sup> | <u>60.0</u>      | 6.7   |
|   |                          |                         |                   | $\bar{X} = 65.2$ |       |
| Mean Intelligibility, Prerecorded Lists         |                          |                         |                   | 63.6             |       |
| Mean Intelligibility, Live Voice <sup>2,3</sup> |                          |                         |                   | <u>68.2</u>      |       |
| Mean Intelligibility, Overall                   |                          |                         |                   | 64.9             |       |

1. Mode 3, Boat A xmits directionally; Boat B receives directionally.  
Mode 4, Boat A xmits directionally; Boat B receives omnidirectionally.  
Mode 5, Boat B xmits omnidirectionally; Boat A receives directionally.
2. Boat A Talker.
3. Boat B Talker.
4. During this run, Boat A was moving at a speed of 15 knots; all other runs were at 2.5 knots.

TABLE 2. Rank Order of the Intelligibility Scores for Three Transmission/Reception Modes

| PRERECORDED LISTS |           |                   |                 |                 |                       |
|-------------------|-----------|-------------------|-----------------|-----------------|-----------------------|
| Rank              | Word List | %INT.             | XMTR Depth (Ft) | RCVR Depth (Ft) | Trans/Recep.          |
| 1                 | A-5       | 79.4              | 400             | > 400           | OMNI/DIR              |
| 2                 | A-11      | 78.2              | 100             | 100             | OMNI/DIR              |
| 3                 | C-11      | 75.4              | 100             | 100             | OMNI/DIR              |
| 4                 | A-9       | 73.4              | 100             | 100             | DIR/DIR               |
| 5                 | B-9       | 68.9              | 100             | 100             | DIR/DIR               |
| 6                 | A-12      | 68.5              | 100             | 100             | OMNI/DIR <sup>1</sup> |
| 7                 | B-12      | 67.2              | 100             | 100             | OMNI/DIR <sup>2</sup> |
| 8                 | B-1       | 54.3              | >400            | 400             | DIR/DIR               |
| 9                 | B-10      | 39.8              | 100             | 100             | DIR/OMNI              |
| 10                | C-10      | 31.0              | 100             | 100             | DIR/OMNI              |
| LIVE VOICE LISTS  |           |                   |                 |                 |                       |
| Rank              | Word List | %Intell.          | XMTR Depth (Ft) | RCVR Depth (Ft) | Trans/Recep.          |
| 1                 | B-14      | 81.0 <sup>2</sup> | 100             | 100             | DIR/DIR               |
| 2                 | C-6       | 66.6 <sup>3</sup> | 100             | 100             | OMNI/DIR              |
| 3                 | C-3       | 65.0 <sup>2</sup> | 100             | 100             | DIR/OMNI              |
| 4                 | C-12      | 60.0 <sup>3</sup> | 100             | 100             | OMNI/DIR              |

1 During this run, Boat A was operating at a speed of 15 knots; all other runs were at 2.5 knots.

2 Boat A Talker.

3 Boat B Talker.

scores for the pre-recorded lists received directionally were obtained when the transmitter and receiver were at two different depths. In one case, however, transmission was omnidirectional but in the low intelligibility condition transmission was directional. There is a suggestion that omnidirectional transmission may be necessary when two boats are submerged to different depths. Theoretical tests of this information are now being carried out.

### DISCUSSION

The results of this study demonstrated certain advantages of using a directional receiving mechanism for intersubmarine voice communications in operating conditions similar to those described in this study. In addition there is a suggestion that when the speed of both ships are equivalent and at a relatively slow rate, intelligibility is higher than when one ship increases its speed. A degree of caution must be exercised in the interpretation of this data since (1) the mode of reception was tested at only one speed and primarily at one depth; (2) mode of reception was investigated at only one range; and (3) the modes of transmission for a given set of equipment under all possible conditions have not been investigated. Thus, it would appear that further tests on reception mode incorporating such variables as depths and speeds of communicating ships, greater ranges, and an investigation of transmission modes in various operating conditions are necessary.

Based on the data at hand, the nature of the speech signal passing through

water would tend to favor a directional receiving apparatus. Sachs et. al. (1969)<sup>2</sup> have reported that an omnidirectional receiver tends to pick up "smear" effects, i.e., multipath interference similar to the echo effect heard in canyons or highly acoustic, reverberent rooms. Concurrent with this information, directional reception may enhance the intelligibility of the signal by omitting the echoic signals received on omnidirectional units. Directional reception also enhances the intelligibility by discriminating against the noise field. The higher intelligibility scores for directional reception appear to be in agreement with the above observations.

While the live voice test scores in this study were found to be superior to the pre-recorded samples, the overall mean was shown to be only five percent greater for the live voice tests. It was observed that there were talker differences in the data and, moreover, there appeared to be talker compensation in one condition. Thus, further tests on transmission and reception modes incorporating various representative depths, speeds, and ranges in addition to a sample of talkers are suggested. The present results do, however, indicate the levels of intelligibility which are possible and indeed obtained during actual operation of two submarines.

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Security Classification

| 14. | KEY WORDS                     | LINK A |    | LINK B |    | LINK C |    |
|-----|-------------------------------|--------|----|--------|----|--------|----|
|     |                               | ROLE   | WT | ROLE   | WT | ROLE   | WT |
|     | Speech Intelligibility        |        |    |        |    |        |    |
|     | Submarine Communication       |        |    |        |    |        |    |
|     | Speech Distortion in Habitats |        |    |        |    |        |    |

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